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FOOD PRODUCTION AND NUTRITION *

UNDER the general title "Food Production and Distribution in relation to Nutritional Needs", the newly established Nutrition Society held a meeting recently. Papers were read by Sir John Orr on "The Agricultural Implications of a Food Policy based on Nutritional Needs", by Dr. N. C. Wright on "Rival Claims of Animals and Man for Food", by Mr. E. T. Halnan on "Animals as Food Converters" and by Sir John Russell on "Planning and Agricultural Production".

After two and a half years of war there is no evidence of a worsening in our nutritional state. Sir John Orr pointed out that, although there are differences between the feeding standards adopted in different countries and by different authorities, these are differences in detail and, broadly speaking, there is now unanimity. At the outbreak of war, both in Great Britain and in the United States, one-third of the population fell below this standard; a decade before that the proportion had been one-half. This improvement gives us some cause for satisfaction, but it is clear that in planning post-war nutrition it is insufficient to aim merely at the restoration of the pre-war state. The consumption of foods such as milk might well be increased by 100 per cent. in Great Britain, and our agriculture should concentrate on the production of perishable productive foods. In many parts of the Empire, for example India, the need is not confined to special foods, for the nutritional condition is appalling, and more of almost every sort of food is needed.

Both during the War and after it is not sufficient merely to consider which crops should be grown; research is needed on the more efficient utilization of existing crops and on their improvement. Sir John mentioned, as an example of the former, the possibility of extracting edible protein from grass, "an idea started two or three thousand years ago under royal patronage", and as examples of the latter the production of vegetables richer than usual in minerals and of oats and wheat with an enhanced vitamin B1 content. The main point brought out in the discussion was the need to ensure that the vitamins originally present in foods such as vegetables are not lost because of the delays in retailing or because of carelessness in cooking. Dr. S. W. Swindells

* Abridged from an article by N. W. Pirie published in *Nature*, Vol. 149, No. 3777, 1942.

spoke of the "planned destruction of vitamin C in canteen cooking" and referred to cases in which incipient scurvy, caused by this cooking, had been mistaken for pyorrhea.

Dr. Wright showed, in a number of different ways, that in pre-war farming in Great Britain animals were predominant; for example, the population weighs approximately two million tons and the livestock five, three million acres were devoted to the direct production of human food and twenty-seven to the production of food for animals, besides which the latter ate two-thirds of the imports. This state of affairs has come about because most people prefer the flavour and small bulk of foods derived from animals, and in peace-time there is no real competition between man and animals; for we get the better parts of the foodstuffs, whether imported or home-grown, and the animals use up the rest. In war-time this luxury cannot be afforded, for animals rarely have an overall efficiency of more than 25 per cent. in the conversion of feeding-stuffs into human food.

The productivity of land devoted to the grazing animal is also low: an acre will yield six million calories in the form of potatoes, or three million in the form of wheat but only one million as milk and 200,000 as meat. The ploughing up of three million acres of grass, 15 per cent. of the total, must therefore be accepted as a wise policy and it should be remembered that it amounts only to restoring the agricultural balance that existed in Great Britain sixty years ago. The best land is generally ploughed; the policy therefore led to the loss of about a quarter of the stock-feed produced by grassland. This, together with the restricted importation of feeding-stuffs, has reduced the available fodder to one-half. In these circumstances Dr. Wright has argued that it would be unwise to divert any more cattle food into human feeding by increasing the percentage extraction of flour. The raising of the extraction rate from 70 to 75 per cent. has reduced the supply of wheat by-products by 400,000 tons and a further rise to 85 per cent. will reduce it by 1,000,000. This fascinating, controversial and extremely complicated subject was not, however, argued in any detail at this meeting.

The question of efficiency of conversion of feeding-stuffs into human food was discussed by several authorities. A simple percentage efficiency rarely expresses the matter adequately because many animals can use feeding-stuffs that could, in no circumstances, be used by man. Even when efficiency is considered in terms of protein only, it should be borne in mind that animal proteins are of higher biological value than some of the plant proteins from which they are made. Young pigs and poultry are the only converters that need a type of food substantially similar to that needed by man. Egg production is as efficient as, or more efficient than, milk production and some of the concentrates at present reserved for the dairy cow might well be released for poultry feeding so long as this food is used primarily for eggs and not for table birds. In the allocation of feeding-stuffs more attention should be paid to individual variation between animals. In general, the young animal is a more efficient retainer of protein and the old a more efficient retainer of calories, laid down in the form of fat. Since protein is the primary deficiency in the war time diet, this would suggest that animals should be slaughtered young, but it can be argued on the other side that the adult pig or ox may be eating food for which there is otherwise no use. So long, therefore, as they are not allowed to compete with men or with the, at first sight, younger and more efficient producers, there is no objection to their retention as producers of fat.

Having considered, at some length, the question of the animal's efficiency, the meeting turned to a brief consideration of our own. Dr. Marrack criticized the inefficient distribution of milk and pointed out that there are fines for selling milk of low fat content but not for selling milk rich in bacteria or low in vitamin A. The lack of any preventive medicine on the farm and the great losses of feeding-stuffs, caused by the prevalence of mastitis and contagious abortion, were stressed by Dr. W. R. Wooldridge. Individual farmers in the same area may get widely different yields with the same crop. Dr. W. K. Slater asked how great the increase in our productivity would be if every farmer were as skilful as the best farmers, but no one was prepared to answer the question.

The various conflicting interests that have conditioned agricultural policy in the past were considered by Sir John Russell. In the first place the cheapest type of farming in Great Britain would be extensive ranching with few workers and much processing; for, except on a strip up the east coast, our best crops are grass and trees. The essence of planning is that we should decide what is wanted and then guarantee the farmer a market for that crop, otherwise he naturally tends to play for safety and farms in the cheapest way possible. Mr. Halnan had said earlier that the conversion of Great Britain into a "dormitory and exercise ground for animals" is sound economics when imported fodder is cheap, and Dr. F. Yates had explained how a labour shortage tends to encourage stock-feeding. Under planned agriculture half our food should be home-grown, but this does not mean that half of each particular food should be; there should be a great extension in milk and vegetable production. This would mean a decline in home production of wheat, butter and other commodities that keep well and so can be easily transported from abroad. It was noteworthy that the policy of increasing the wheat acreage, except as a purely war-time measure, found no support from any speaker at the meeting; instead there was substantial unanimity that Great Britain should adopt a policy somewhat similar to the peace-time policy of Denmark.

CACAO INDUSTRY OF TRINIDAD

Summary of Results of Detailed Examinations of Certain Fields in Rio Claro, Moruga and Toco Districts of Trinidad

BY

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Introduction

DETAILED field examinations similar to those already carried out by Shephard in the Montserrat District, have been extended to three other cacao growing districts of Trinidad covering seventeen fields and approximately 22,000 pickets.

Variation in Field Yield

Average field yields varied from 500 lb. per acre to less than one-third of that figure—150 lb. per acre. Using Shephard's assumptions for a conservative measure of profitability—that is cacao averaging 6 cents (3*d.*) per lb. and adequate cultivation costs of $21.00 (£4 7*s.* 6*d.*) per acre—the most productive field would make a profit of $9.42 (£2 1*s.* 3*d.*) per acre ; the least productive under the same conditions a loss of $12.00 (£2 10*s.* 0*d.*) per acre. This difference in productivity is not so wide as the extremes observed in the Montserrat District, where yields of as high as 660 lb. per acre and as low as 75 lb. per acre have been recorded. Of the fields in three districts those in Moruga averaged the highest yield, 363 lb. per acre and those in Toco the lowest, 210 lb. per acre. In Rio Claro they averaged 330 lb. and over the whole three 312 lb. per acre. This average yield of 312 lb. per acre is a slightly unprofitable one by the foregoing standards.

Very considerable variation in field yields was also noted within individual estates. On three estates more than one field was examined and a wide spread in productivity was observed in each case: on one estate the extremes were 507 lb. and 264 lb. per acre ; on another 477 lb. and 195 lb. per acre ; and on the third 483 lb. and 225 lb. per acre. Acre for acre from one-half to almost the whole of the profits earned on the most productive fields were absorbed in making up the losses on the unproductive ones.

Variation in Picket Yield

A similar wide variation in the yield of individual pickets was observed in the three districts as had been noted in Montserrat. Forty per cent. of the pickets in the three districts yielded nothing; 28 per cent. from .1 to 1.0 lb., that is an unprofitable yield ; the remaining 32 per cent. gave profitable yields up to a more or less indeterminate maximum, one-half of one per cent. of all pickets yielding more than 9 lb. of cacao per annum. From the point of view of yield distribution the fields in the three districts were intermediate between the extremes in the Montserrat district ; no field had as few as 15 per cent. or as many as 63 per cent. of the pickets non-bearers.

From the yield distribution the supposition is that indifferent yields are due more to relative lack of cultivation in the three districts than to inherently poor soils. In Montserrat on the poorest soil pickets yielding more than 5 lb. per annum were practically non-existent; in the three districts, 3½ per cent. of all pickets gave over this yield and contributed about 24 per cent. of the total ; nevertheless 68 per cent. of all pickets were unprofitable, a figure far higher than on the good soils of Montserrat.

Without exception high and low yielding pickets occurred scattered at random throughout the fields. There was no evidence that any appreciable amount of the picket variation was due to fertility or suitability trends throughout any field.

In spite of the relatively high frequency of non-bearing pickets, the supplying rate in these seventeen fields was extremely slow. On the whole, only 3½ per cent. of the pickets were surviving supplies between 1–4 years old ; these supplies amounted to only 8½ per cent. of the non-bearers. Thus at the existing supplying rate it would take at least 50 years to supply the non-bearers alone even supposing no further tree casualties occurred in the interval. The fields in the Moruga district showed the most rapid replacement of non-bearers, 11 per cent. of them per 5 years and in Rio Claro the least rapid (about 7 per cent.).

Two fields on one estate gave excellent evidence of misjudged supplying policy. One field yielded at the rate of 477 lb. per acre and the other at only 252 lb. per acre ; and yet there was actually a larger number of supplies and fewer non-yielding pickets on the poor than on the good field ; in the poor field no less than one-quarter of the pickets were surviving supplies (up to 35 years old) whereas on the more productive field only one-seventh was supplies. The few supplies in the good field yielded half as much again per tree as on the poor field.

In other fields it was noted that numerous supplies had been planted when the yield of the original trees in the field (which yield consistently higher than any other age group) was actually unprofitable. Supplies in fact were being planted when there was no chance of ordinary seedling stocks ever being likely to become profitable.

Influence of Soil on Yield

With a less compact province than the Montserrat District it was not possible to make such clear cut comparisons as to soil differences in the three districts. The most marked soil contrasts were observed in the Rio Claro District in which there is no doubt that the Princes Town Marl soil

was greatly superior to any other for cacao cultivation. The other types (two types of clay soil containing pockets of alluvium and colluvium) were generally unprofitable and are not recommended for continued cultivation of cacao.

In the other two districts only one or two (three in one case) fields were available as representing a particular soil type. It is therefore impossible to draw fine comparisons. In Toco, however, the Quartz Schist and Igneous Rock soils were clearly unprofitable. In Moruga the age of field appeared to have an important influence on the fertility of the soil. Most soils were productive when young but showed evidence of rapid depreciation with age. No soil type was actually unprofitable when the field was less than thirty years old, but of the three main types, the Marly Clay seemed to be the least suitable soil type.

Assessment of Suitability of Soil Type

Owing to this influence of age of field on soil and variation in the past management of fields it was considered undesirable to assess suitability of soil entirely from average field yields. Instead, the average yield of original trees in the field was taken as the standard. It was assumed that any field which contained original trees yielding on the average less than 1½ lb. per tree, did not warrant the continuation of traditional cultivation standards. The yield of 1½ lb. was taken because in a well managed field it should be possible to secure 75 per cent. of mature trees and 25 per cent. supplies ; with this age distribution it would be necessary to secure 1½ lb. on the 75 per cent. in order to obtain a profitable yield over all. The possibility of planting high bearing cuttings in the future, did not invalidate this basic calculation of the suitability of soils.

Table 1 classifies the soils in the three districts and Montserrat on the basis of yield of original trees.

Influence of Age of Field on Yield

No fields were available in Toco for a comparison of the effect of different ages of cultivation. In Rio Claro a comparison could be made only on one soil type (Princes Town Marl) and in Moruga on two (Moruga Marly Silt and Moruga Yellow Sand).

It was striking that on Princes Town Marl no depreciation in yield was observed between the ages of 20 and 42 years. The yield of both the fields was profitable and the high yields of the older field was achieved primarily by the high yield of original trees, which seemed to increase over the age range to such an extent as to counteract loss from casualties. The good wearing qualities of Princes Town Marl definitely recommend it as a cacao soil.

The two fields on Moruga Marly Silt were 25 and 40 years old and it was seen that unlike Princes Town Marl this soil depreciated rapidly. Further, it depreciated from a very profitable yield (500 lb. per acre) to an unprofitable one (264 lb. per acre). A similar marked depreciation was observed on Moruga Yellow Sand between the ages of 40 and 60 years, from 483 lb. to 225 lb. per acre ; there is evidence that the yield on Moruga Yellow Sand at less than 40 years would be even higher than 483 lb. per acre ; that is, that at 40 years soil depreciation had already set in. Indeed, it appeared to be a characteristic of the Moruga district that age of field very largely determined productivity and not soil type ; whereas in Rio Claro it was soil type and not age of field that appeared to be the influencing factor.

Table I.—Suitability of certain Trinidad Soils for continued Cacao Cultivation

District.	*Previous Name.*	*Recent Name.**
	SUITABLE.	
Rio Claro	Princes Town Marl	Princes Town Heavy Clay.
Moruga	Moruga Silt	Moruga Loam.
	Basse-Terre Marly Silt	Marper Silt.
Toco	Calcareous Schist	Caroni Sand.
Montserrat	Chocolate	Montserrat Clay Silt (A).
	Brasso Sand	Montserrat Loam (B).
	Alluvial	L'Ebranche Clay Silt.
	UNSUITABLE.	
Rio Claro	Naparima Red Clay	Talparo Clay.
	Other and Mixed Clays	Brasso Clay. Ecclesville Clay.
Moruga	Basse-Terre Marly Clay	Marper Silt.
Toco	Quartz Schist	Toco Loam.
	Igneous Rock	Sans Souci Loam.
Montserrat	Brasso Clay	Ecclesville Clay.
	DOUBTFUL.	
	(Worthy of cultivation and improvements only on limited areas and young fields.)	
Moruga	Moruga Marly Silt	Marper Silt.
	Moruga Yellow Sand	Caroni Sand.

* Recent names used for reference to: Hardy "Provisional Classification of Soils of Trinidad", *Tropical Agriculture*, Vol. XVII, No. 8, p. 153.

Field Improvement

The findings on these fields confirm and widen the findings in Montserrat. The improvement policy recommended by Shephard for Montserrat is equally applicable to the three districts. The most productive fields in the three districts contain between 40 and 60 per cent. of unprofitable pickets, most of which could be replaced to advantage. The elimination of unprofitable fields from estates (also recommended by Shephard), is also confirmed by the general variation in field yields and particularly by the variation actually found within individual estates.

The fact that genetically more uniform planting material in the form of cuttings is becoming available in quantity, does not modify the recommended improvement policy. These field examinations show that there is sufficient scope for improvement in the profitable fields alone to absorb a very large supply of cuttings, and bring about substantial improvements in the fields.

A NOTE ON ECOLOGICAL PHOTOMETERS WITH SPECIAL REFERENCE TO RECTIFIER (SELENIUM) CELLS *

BY

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Ecological photometry makes use of many types of apparatus, but these usually employ one of four basic methods of measuring radiation. Light may be measured (1) in terms of the heat it produces, (2) by its chemical effects, (3) by illuminometers which depend on the human eye for the comparison of light intensities, and (4) by the amount of electrical energy into which it may be transformed. These four methods may be made selective for different wave bands by the use of suitable filters or screens. In general, comparative readings are required and not accurate absolute values. For more complete accounts of light measuring methods the reader is referred to the works of Klugh (1925, 1927), Shelford (1929), Chapman (1931) and Shirley (1931).

Of the instruments that measure light by heat effects, the most commonly used is the pyrheliometer which consists of a suitably mounted thermopile. Such instruments can be very sensitive, but are most responsive to the red end of the spectrum. They are usually too delicate in construction for general field work especially in the climate of the damp tropics. Livingston atmometers may be used for the integration of light effects over long periods. Here the excess of evaporation from the black bulbs, as compared with the white, is taken as an index of the amount of radiant energy absorbed.

The only satisfactory photo-chemical photometers are those making use of sensitized paper, films or plates. In general, these are most responsive to light of short wave lengths, but the use of panchromatic films or plates (Klugh 1925), or of Rhodamine B paper (Klugh 1927) extends their range of spectral sensitivity.

Illuminometers are of many types. The most elaborate contrast the light to be measured with that produced by a standard lamp contained in the instrument. Simpler forms make use of diaphragms or neutral wedges. These photometers measure the whole of the visible spectrum, and are of great value for ecological work being portable, robust, and capable of rapid operation. The possibility of error due to the human element must, however, be considered.

Photo-electric cells are of two types. The first, or emission, type depends on the property of thin films of metal of the caesium series to emit electrons when exposed to light. If such a film is incorporated into the cathode of a vacuum or gasfilled valve, the amount of electronic emission may be measured. Since this emission is proportional to the intensity of the incident radiation, the valve or cell may be calibrated for photometric purposes. In general such cells are most sensitive to light of short wave lengths, but the addition of silver to the deeper layers of the film may give increased response to the red end of the spectrum.

The second, or rectifier, type of photo-electric cell makes use of the property of certain compounds of selenium to generate an electromotive force when exposed to light. The current produced by this e.m.f. is directly proportional to the intensity of the incident light provided that the resistance of the outside circuit is small. (In the case of a circular cell with a sensitive surface 37 mms. in diameter, small = 100 ohms or less). This current may be measured by a microammeter giving a direct index of the light intensity to which the cell is exposed. The spectral sensitivity of the rectifier cell approximates to that of the human eye. The advantages of such a photometer are (1) it is portable, (2) it is instantaneous in action and easy to read, (3) the human element is largely eliminated, and (4) the sensitive surface of the cell is small and exposable in any plane. This last enables the cell to give an index of the light reaching individual leaves. Consideration of these advantages has led to the use of this type of photometer in recent work by Jordan (1941), Cobley (1942) and Darling (1942) on problems of cacao cultivation.

* The writer is indebted to the General Electric Company, Ltd., England, for advice on photo-electric cells.

The rectifier cell is most suitable for measuring light of low intensities. When used for field ecological work in the tropics its accuracy may temporarily decrease due to temperature and fatigue effects. For each degree centigrade of rise in its temperature the output of the cell falls by 0.3 per cent. Since exposure to tropical sunlight may cause a 20°C rise in cell temperature the error from this cause may approach 7 per cent. The fatigue effect becomes important when light intensities are greater than 538 lux (50 foot candles). In stronger light the output of the cell will fall during the first half hour of exposure, and will then become more constant. This loss of output is directly proportional to the light intensity, and is slowly restored if the cell is kept in the dark. The rate of restoration in the dark is inversely proportional to the light intensity to which the cell has been previously exposed. When very high and very low light intensities are being compared, the error due to fatigue may be up to 30 per cent. In surveys made by the writer (1942) in Trinidad, B.W.I., light intensities in cacao fields, as measured by a naked rectifier cell, ranged from 10 to 95 per cent. of full sunlight. Under such conditions the possibility of large photometric errors cannot be ignored. Neutral filters which decrease incident radiation to a known extent would largely eliminate the effects of temperature and fatigue. Their use with this type of cell is therefore recommended for field ecological work in the tropics.

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OBITUARY

Dr. RAYMOND L. DITMARS.

By the death of Dr. Raymond L. Ditmars on 12th May at the age of 66, the world has lost a distinguished naturalist and an outstanding authority on reptiles. He was, for a number of years, Assistant Curator of Entomology at the American Museum of Natural History. In 1899 he was appointed Curator of reptiles at the New York Zoological Park, and in 1910 made Curator of Mammals and Reptiles, which post he held up to the time of his death. He was a Fellow of the New York Academy of Sciences and of the New York Zoological Society, and a Corresponding Member of the Zoological Society of London.

Dr. Ditmars contributed numerous scientific papers on various subjects, published mainly by the New York Zoological Society. He was very widely known also as author of numerous books on natural history, many of which deal with reptiles and are illustrated by remarkable photographs. Among the best known of his books are "Reptiles of the World", "Snakes of the World", "Thrills of a Naturalist's Quest", etc., and in collaboration with Mr. William Bridges, "Snake-Hunter's Holiday". The latter gives a graphic account of one of his most successful expeditions in 1934. This was to Trinidad, where he obtained a live bushmaster and live vampire bats, which were subsequently placed on exhibition at the New York Zoological Park. Intense public interest has always attended his expeditions, and it is estimated that some hundred thousand persons visited the Zoological Park to see these exhibits.

Dr. Ditmars travelled extensively and during his various stays in Trinidad visited the College on several occasions. His most recent visit here was in September of last year. When he took back with him to the United States, for exhibition in the New York Zoological Park, many live specimens, including a number of snakes, a colony of parasol ants, three paradox frogs and nineteen vampire bats.

Dr. Ditmars, apart from his great knowledge of reptiles and faculty for vivid descriptive writing, will long be remembered for his endearing personality. He made many friends and those who were privileged to know him will feel a very real loss.

NITROGEN UPTAKE BY GRAPEFRUIT TREES

Studies were made in two groves which had not received fertilizer for some years in the Salt River Valley, Arizona. They concerned the time of application and the quickness of response of grapefruit trees of different age to different nitrogenous fertilizers. Nitrogen was taken up most rapidly from calcium nitrate, followed by urea, ammonium sulphate and farmyard manure in that order. The time of application producing the highest nitrogen in the new leaves was February for calcium nitrate, December for urea and ammonium sulphate and August for the manure. —(*Horticultural Abstracts*, XII, No. 1.)

OBSERVATIONS ON THE EXPERIMENTAL PERFORMANCE OF THREE STOCKS FOR W. I. LIME IN MONTSERRAT

BY

R. G. FENNAH

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BETWEEN 27th and 30th September, 1937, an experiment was laid down by courtesy of the Montserrat Company near the Grove Botanic Station, Montserrat, with the purpose of revealing which, if any, of three stocks for West Indian Lime was suited for general use under local conditions. The stocks tested included Rough Lemon, Sour Orange and Seville Sweet Orange (locally termed "Silver Sweet"). The layout employed was a 4 × 4 Latin square, with sixteen trees in each plot; the fourth member of the series of types was a control of West Indian Lime grown from seed. The Rough Lemon and Sour Orange stocks were raised from seed imported from Trinidad, the Seville Sweet from the seed of a tree selected locally, while the West Indian Lime used in the control plots and in the guard rows was also of local origin.

Conditions of Growth

All the experimental material suffered from damage at the roots by larvae of citrus weevils (*Diaprepes*) in the nursery beds and in the field. After being transplanted the young trees were exposed to drought and wind, especially in the eastern half of the experiment, which, unlike the western half, was not protected by windbreaks. The wind here, as generally in the West Indies, almost always blows from some easterly point of the compass. The adverse effect of these factors was increased by the very light texture of the soil in which the trees were grown. The nutrient status of the soil in the plots is not known to the writer, but several analyses* of similar soil taken from fields close at hand support the belief that there has been at least no deficiency in major elements required for healthy growth. The meteorological conditions which have prevailed during the course of the experiment were recorded about 300 yards west of the site, and are reproduced in summarised form in Fig. 2. An important point is that much of the annual rainfall occurs in a few torrential downpours, the good effect of which is short-lived owing to the exceptionally free drainage of the soil.

In the early part of 1939 the condition of the plots had deteriorated so much that it was considered advisable to replace the grass growing between the trees by the leguminous cover-crop *Tephrosia candida*, which was calculated to provide shelter from wind, and, when cutlassed, to increase the supply of nitrogen in the soil. In 1940, in order to reduce the continuously high population of *Diaprepes* in the plots, lead arsenate was applied to the soil around the roots of the trees.

* Kindly made by the Department of Soil Science, I.C.T.A.

Collection of Data

The experiment was inspected seven times between 30th September, 1937 and 6th January, 1942, as follows: (1) 25th April, 1938, (2) 1st January, 1939, (3) 3rd May, 1939, (4) 20th September, 1939, (5) 1st March, 1940, (6) 14th May, 1941 and (7) 6th January, 1942. All examinations were made by the writer, with the exception of the third, which was carried out by Mr. W. R. E. Nanton, of the Montserrat Department of Agriculture. The general condition of each tree (as judged from height, vigour, number of branches, and density of foliage) was recorded, and also, except on the third examination, the colour of the foliage (if abnormal), the presence of dead wood, and of Green Scale (*Coccus viridis* Green). As trees or scions died they were replaced or rebudded, but for subsequent records such trees were classed as having died.

Results

The results of all the inspections are shown in Figure I. For the purpose of comparing trees three categories were established, (A) healthy and average, (B) very unhealthy or moribund, (C) dead, replaced or rebudded, and every tree was assigned to its appropriate group on the basis of its rating in the penultimate and final inspections. The number of trees of each type in each category is given in the following table:—

Stock	A	B	C
Rough Lemon ...	48	0	16
W. I. Lime ...	43	9	12
Seville Sweet ...	30	13	21
Sour Orange	18	27	19

A difference of 20.8 between the figures in column A or of 17.5 between those of column B is significant. Differences between the figures in column C are not significant.

The trees budded on Rough Lemon and the control of West Indian Lime have proved significantly superior in general health to those budded on Sour Orange under the conditions which have prevailed. Trees budded on Seville Sweet Orange have not proved significantly superior to those on Sour Orange, nor significantly inferior to the remaining two. It is concluded that Rough Lemon is to be preferred to Sour Orange as a stock for lime trees in areas subject to environmental conditions similar to those described*.

* It should be noted that Wild Grapefruit, a very promising stock for limes, has not yet been compared with Rough Lemon under these conditions.

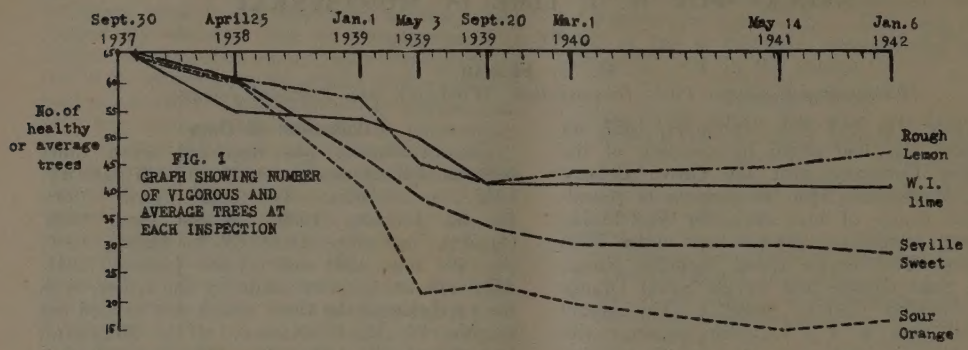

FIG. 1 GRAPH SHOWING NUMBER OF VIGOROUS AND AVERAGE TREES AT EACH INSPECTION

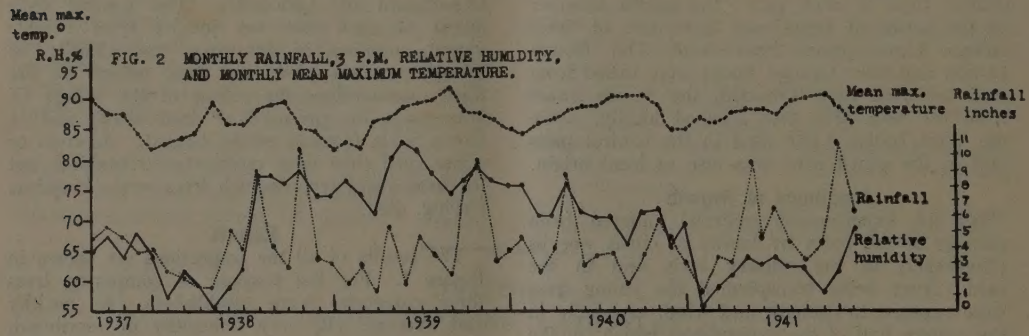

FIG. 2 MONTHLY RAINFALL, 3 P.M. RELATIVE HUMIDITY, AND MONTHLY MEAN MAXIMUM TEMPERATURE.

In view of the fact that between a quarter and a third of the original number of budded trees of each variety has died completely or as far as the stock since the beginning of the experiment it is clear that environmental conditions have been distinctly severe. The principal factors adversely affecting growth have been drought, exposure to wind, damage at the roots by *Diaprepes*, and infestation by scale-insects. Of these, lack of water and damage by *Diaprepes* may be presumed to have affected all plots indiscriminately. As already mentioned it was possible for wind to sweep over the eight plots lying in the eastern half of the experiment before striking the windbreak which protected the western half. The effect of this relative exposure is reflected in the number of trees which have died. The total number of trees which have died or been rebudded in the eastern half is 48, and in the western half 20. These totals are very significantly different.

Infestation of trees by Green Scale has been frequent and usually heavy. A representative picture of the manner in which the infestation was spread over the experimental area and over the different types of tree is provided by the combined results of four inspections which coincided with periods of heavy incidence of attack. The numbers of infested trees of each variety in the eastern and western halves of the experiment derived from the four sets of data are given below.

Stock	Eastern field (exposed)	Western field (sheltered)	Total
Rough Lemon	41	10	51
W. I. Lime ...	30	15	45
Seville Sweet	40	10	50
Sour Orange	51	34	85
Total ...	162	69	231

The eastern field is very significantly more heavily infested than the western. Differences in infestation between the four types of tree are not significant.

It can thus be seen that the eastern field, beside losing more trees, suffered more heavily from scale-insect attack than its sheltered counterpart.

Summary

In an experiment designed to compare three stocks of lime trees, Rough Lemon, Sour Orange, and Seville Sweet Orange with West Indian Lime, Rough Lemon was found to be significantly superior to Sour Orange. Seville Sweet Orange was not significantly better than Sour Orange, while the latter was significantly inferior to West Indian Lime. A greater number of inferior trees occurred on the wind-swept eastern half of the experiment, where also infestation by Green Scale was heavier.

THE DETERIORATION OF HARVESTED SUGAR CANE

A Preliminary Study of Varietal Trends in Egypt

BY

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A few years ago the writer published in *Tropical Agriculture*, under the same main title (16), the results of four series of experimental studies of dryage and deterioration after cutting of Egypt's Standard cane, POJ 105, during the latter months —March and April—of the campaign in Middle Egypt. Each experiment ran for eight days after cutting and the results indicated—as might be anticipated—increasingly greater losses from both evaporation and inversion as the days became longer and warmer and atmospheric humidity decreased—which are the normal climatic trends during the Egyptian cane harvest season from January to April.

The average results for the four series of tests, which, as a basis of comparison with the present experiments, are shown in Table I, were, in brief:

(i) The eight-day loss by evaporation amounted to 17 per cent. of the original cane weight, of which almost 11 per cent. occurred during the first four days, a period over which cane deliveries are not infrequently delayed.

(ii) The total drop in juice purity was one of 24.5 degrees, of which almost three-fourths (17.7 points) took place in the first half of the period, that for the first day being negligible, but rising to close to six points for each of the next three days.

(iii) The increase in the vitally important invert sugar coefficient totalled 27.3 points, over two-thirds (18.7 points) in the first four days. Here again the difference was negligible for the first day, but the rise averaged 5.5 points for the following three days.

(iv) The final outturn in kilograms of sugar recovered per ton of cane ground dropped from 95 extracted from the fresh cane to but 35 on the eighth day, almost three-fourths (44 Kgms.) by the fourth day. Since the juice appears to be merely concentrated by the first day's heavy evaporation, no factory loss was indicated over the first 24-hour period, but for the following three days it averaged close to 15 Kgms. per ton per day. After the fourth day the decrease was at the rate of only about 4 Kgms. daily.

Varietal Susceptibility to Inversion

Hall (11), chemist of the Tucumán Sugar Experiment Station in Argentina in 1913, was apparently the first investigator to record that the rapidity and completeness of inversion vary specifically with distinct cane varieties. He demonstrated (2) that the series of Java varieties of which POJ 105, the cane most commonly grown in Egypt, is typical, are much more susceptible to rapid deterioration than noble canes of the Cheribon type. As an example of his important findings it may be mentioned that when he left the two types cut for twelve days under the same conditions, from initial purities in both cases of 86.8 per cent. the POJ 36 dropped to 59.4 per cent. while the Louisiana Striped (Baladi in Egypt) fell only to 77 per cent. purity. His conclusions were confirmed by the present writer (13) and Cross and Belile (8) in Argentina and since by workers (4, 9, 10, 12, 14 *et al*) in most of the countries where the earlier series of POJ or similar types of cane have been grown.

Cross (8) who succeeded Hall at the Tucumán station, continued his predecessor's deterioration studies and, after a prolonged series of experiments, concluded that inversion is largely due to invertase and possibly other enzymes in lesser degree. The Cheribon canes, which had been for years recognized as deteriorating slowly, and POJ 2725, to

TABLE I

Mallawi Evaporation and Deterioration Tests (1)

	Days after Harvest									Total Drop
	0	1	2	3	4	5	6	7	8	
Weight of Sample—Kgms.	200	193	187	183	178.5 (90%)	176.5	171.5	168.5	166.0	34 (17%)
Sucrose in Cane—% ...	11.97	12.19	11.37	11.19	10.24	10.0	9.87	9.94	9.75	2.22
Purity of Juice—% ...	80.6	80.1	73.7	68.9	62.9	61.4	58.7	57.1	56.2	24.4
Glucose Ratio—% ...	7.1	8.5	15.0	20.2	25.8	28.3	30.9	33.6	34.4	+27.3
Kgms. Recov. Sugar per Ton Cane ...	95	95	78	64	51 (54%)	46	43	39	35	60 (63%)

(1) Average results of four experiments with POJ 105 variety.

which the present writer (15) and others* have called attention as a very slowly inverting variety, were found to have a relatively low enzyme content. Browne (3a) had previously demonstrated the presence of invertase in *immature tops only*, but Cross appears to have been the first to recognize the presence of this enzyme in the mature stalk and to suggest that the larger invertase content of the newer varieties is mainly responsible for their more rapid inversion rate.

Another variety which has demonstrated exceptional keeping qualities similar to those of POJ 2725 in widely scattered countries is Co 281, while several other canes in that group have been shown to possess this character in varying degree. Haldane (10), for instance, mentions Co 213 as "a variety which does not deteriorate as rapidly as other Coimbatore or other indigenous varieties" and Co 205 as "well-known to deteriorate rapidly." In Louisiana, Co 281, although it has, according to a recent report by Arceneaux, Gibbens and Krumbhaar (1), "again proved the least productive of varieties now in extensive commercial culture," is still recommended for planting as a windrowing cane, since it has been frequently demonstrated that, if windrowed in advance of a killing freeze, it will keep for several weeks, during which the more productive but less stable varieties, such as Co 290, may be ground, with even less inversion than was shown by the Louisiana Purple and Striped cane in its pre-mosaic disease heyday. Arceneaux *et al* conclude:

"The observed average yield of sugar per acre from this variety approximating 7,000 pounds below that from Co 290 in the aggregate of plant cane, first and second stubble crops emphasizes the importance of keeping the acreage devoted to Co 281 down to minimum proportions consistent with expected windrowing requirements."

Finally, as regards frozen cane, Lauritzen, Fort and Balch (12a) consider that:—

"The results relating to inversion of sucrose in frozen cane of the varieties Co 281 and Co 290 justify the same grouping as employed for unfrozen cane. Although certain lots of Co 290 show high resistance to inversion, others show considerable susceptibility to it."

A Preliminary Experiment at Nag-Hamadi

At the Egyptian General Sugar Company's factory and plantations located at Nag-Hamadi, about 75 miles north of Luxor, the manager, Mr. R. Roche has, during the past decade been experimenting with and gradually extending the area of POJ 2878 until today there are some 1,750 acres of this variety in cultivation. He has also maintained some 300 acres of the Cheribon canes. In the last few years both Co 281 and Co 290 have shown considerable promise in the writer's experiments and some 25 acres are now under commercial cultivation at Nag-Hamadi. Co 281 is also being tried in areas of several acres widely scattered over the entire cane belt.

During the 1941 crop Mr. Roche's cooperation was enlisted for carrying out a preliminary deterioration test with the above-mentioned four varieties in comparison with our standard POJ 105 using practically the same technique employed in the Abou-Kourkas trials. Mr. Ismail Sabry was delegated to supervise the experiment and the writer gratefully acknowledges his careful attention to all the intricate details. The procedure adopted was as follows:—

On the morning of 26th March, 1941, about 1/50th of an acre of excellent first-year stands of all five varieties were cut out and sent to an enclosed area near the factory, there being approximately a ton of each. In order to obtain as even lots as possible, the canes of each variety were divided into two series comprising those of larger and smaller diameter, which were mixed as regularly as possible when the varieties were in turn divided into piles of 50 Kgms. each. Twelve such lots were prepared for each variety and numbered 0 to 11, the first being used for the determinations made three hours after cutting and the successive ones for the weights and analyses carried out each morning at the same hour after one to eleven days, respectively. In order to maintain comparison with the previous experiments, only the figures up to eight days after cutting are considered in this paper. As a matter of fact, cane deliveries are rarely delayed more than four days and it is considered that for factory purposes the comparative alteration of the distinct varieties can best be judged at the end of that period.

The sixty lots were distributed over the enclosure in such a way that they were all equally exposed to the sun, care being taken not to have any piles closer than fifteen metres from a wall, in this way simulating as closely as possible the normal exposure of harvested cane in the field. It would have been better to have employed from four to six replications of each "treatment" but limitations of both storage space and laboratory time would have made the handling of a minimum of some 250 samples a very exacting procedure. Hence, it was considered a simpler and more "foolproof" process to conduct this preliminary trial along the same lines as each of the four seasonal experiments made at Mallawi. With the indicated trends of the present Nag-Hamadi tests in mind, it is proposed during the coming crop at Nag-Hamadi to carry out four successive experiments with the five varieties during March and April. While the effect of changing climatic conditions on varietal alterations are thus being studied, it is felt that the four seasonal repetitions may also serve in considerable degree as replicates, thus materially lowering the experimental error.

The figures in Tables II and III which are presented graphically seem to require little comment and this will be largely based on the results up to four days after cutting, since during the last half of the period some of the curves, particularly those for POJ 2878, became somewhat aberrant.

* *Vide* Chardon, C. F.—La Cana POJ 2725, *Pto. Rico Ins. Expt. Sta. Bull.* 34, 1928.

TABLE II

Nag-Hamadi Evaporation and Deterioration Tests

	Days after Harvest									Total Drop
	0	1	2	3	4	5	6	7	8	
(*I*) *Black Cheribon.*										
Loss in Weight —% ...	—	4.0	6.4	6.6	8.1	9.5	11.9	12.8	14.9	14.9
Sucrose in Cane —% ...	12.96	12.50	12.42	12.01	11.93	12.23	12.01	12.56	11.36	1.6
Purity of Juice —% ...	85.6	82.2	80.3	77.4	72.6	71.9	70.5	69.3	66.2	19.4
Glucose Ratio —% ...	5.4	6.7	7.8	11.7	12.6	20.1	21.6	24.8	26.7	+21.3
Kgms. Recov. Sugar per Ton Cane	108.0	101.0	98.0	91.0	83.0 (77%)	85.0	81.0	84.0	67.0	41.0 (38%)
(*II*) *Co* 281.										
Loss in Weight —% ...	—	8.3	8.5	12.1	11.7	11.7	12.1	13.6	18.1	18.1
Sucrose in Cane —% ...	13.24	13.11	12.87	12.23	12.75	13.39	12.86	12.86	11.8	1.44
Purity of Juice —% ...	85.1	83.2	80.3	79.3	75.0	74.3	70.5	68.9	63.9	21.2
Glucose Ratio —% ...	3.8	5.6	7.0	9.9	14.0	15.4	20.0	23.7	28.4	+24.6
Kgms. Recov. Sugar per Ton Cane	110.0	102.0	102.0	95.0	95.0 (86%)	99.0	89.0	88.0	69.0	41.0 (37%)
(*III*) *Co* 290.										
Loss in Weight —% ...	—	2.1	4.2	7.7	8.1	8.0	8.8	10.7	14.3	14.3
Sucrose in Cane —% ...	13.28	12.90	12.03	12.0	11.03	10.92	11.31	11.0	10.66	2.62
Purity of Juice —% ...	83.8	80.7	74.3	74.0	64.3	62.6	62.7	60.0	58.1	25.7
Glucose Ratio —% ...	5.2	7.6	14.8	15.2	29.0	32.6	33.4	34.4	41.6	+36.4
Kgms. Recov. Sugar per Ton Cane	111.0	104.0	90.0	89.0	70.0 (64%)	67.0	69.0	64.0	58.0	53.0 (48%)
(*IV*) *POJ* 105.										
Loss in Weight —% ...	—	6.9	7.1	8.1	10.0	12.9	13.6	13.6	15.9	15.9
Sucrose in Cane —% ...	14.50	14.33	13.60	13.38	12.77	12.51	12.46	12.46	12.6	1.9
Purity of Juice —% ...	87.8	85.4	81.4	77.8	70.5	66.1	64.9	64.7	63.4	24.4
Glucose Ratio —% ...	2.3	4.9	6.8	11.3	20.7	27.6	30.1	31.0	31.5	+29.2
Kgms. Recov. Sugar per Ton Cane	124.0	120.0	110.0	104.0	89.0 (72%)	79.0	77.0	77.0	76.0	48.0 (39%)
(*V*) *POJ* 2878.										
Loss in Weight —% ...	—	2.3	5.8	6.6	7.7	11.4	13.5	13.8	16.6	16.6
Sucrose in Cane —% ...	12.97	11.91	11.98	11.67	11.31	11.83	11.89	12.11	12.13	0.84
Purity of Juice —% ...	83.8	78.5	76.8	72.5	68.8	69.3	68.1	67.4	66.8	17.0
Glucose Ratio —% ...	6.1	9.4	12.5	17.8	23.6	26.3	24.7	26.1	27.0	+20.9
Kgms. Recov. Sugar per Ton Cane	109.0	94.0	92.0	86.0	78.0 (72%)	83.0	82.0	82.0	82.0	27.0 (25%)
Max. Temp. Deg. Cen. ...	31.0	32.5	38.0	28.7	33.0	33.0	37.0	36.0	36.0	Ave. 33.9

TABLE III

Comparative Drop in Purity, Recoverable Sugar and Cane Weight after 4 and 8 days (in percentages of original figures)

Variety	Purity		Sugar per Ton Cane		Cane Weight	
	4 days.	8 days.	4 days.	8 days.	4 days.	8 days.
Co 281	11.9	24.9	14	37	11.7	18.1
Cheribon	15.2	22.7	23	38	8.1	14.9
POJ 2878	17.9	20.3	28	25	7.7	16.6
POJ 105	19.7	27.8	28	39	10.0	15.9
Co 290	23.3	30.7	36	48	8.1	14.3

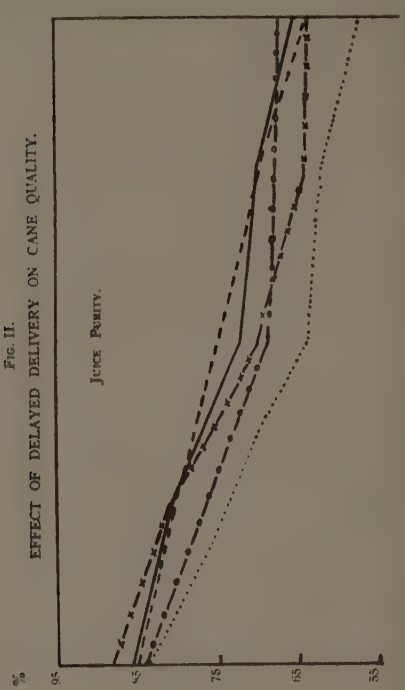
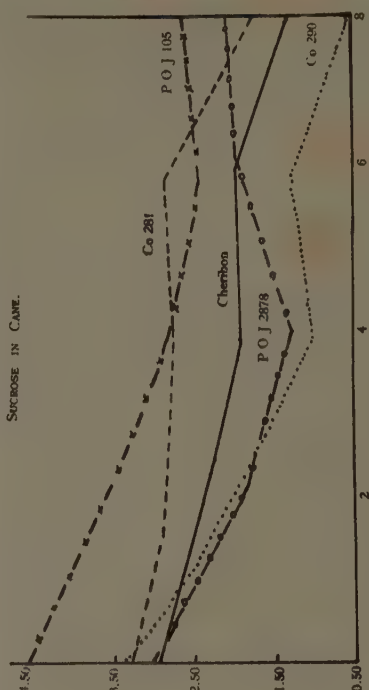


Fig. II.
EFFECT OF DELAYED DELIVERY ON CANE QUALITY.
Juice Purity.
%
95
85
75
65
55


Sucrose in Cane.
Co 281
P O J 105
Cheribon
P O J 2878
Co 290
14.50
13.50
12.50
11.50
10.50
2
4
6
8
Days after Cutting

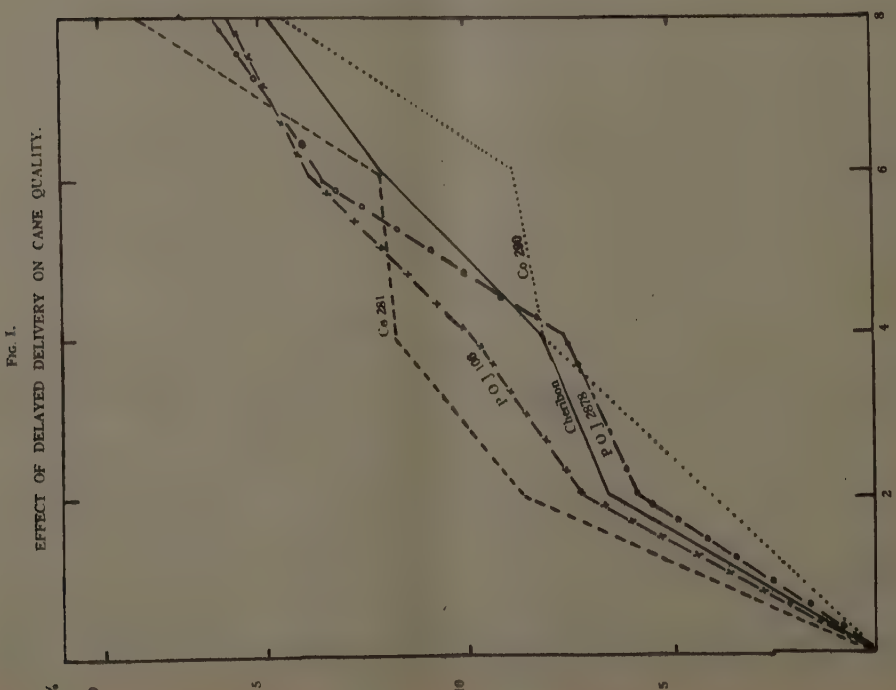
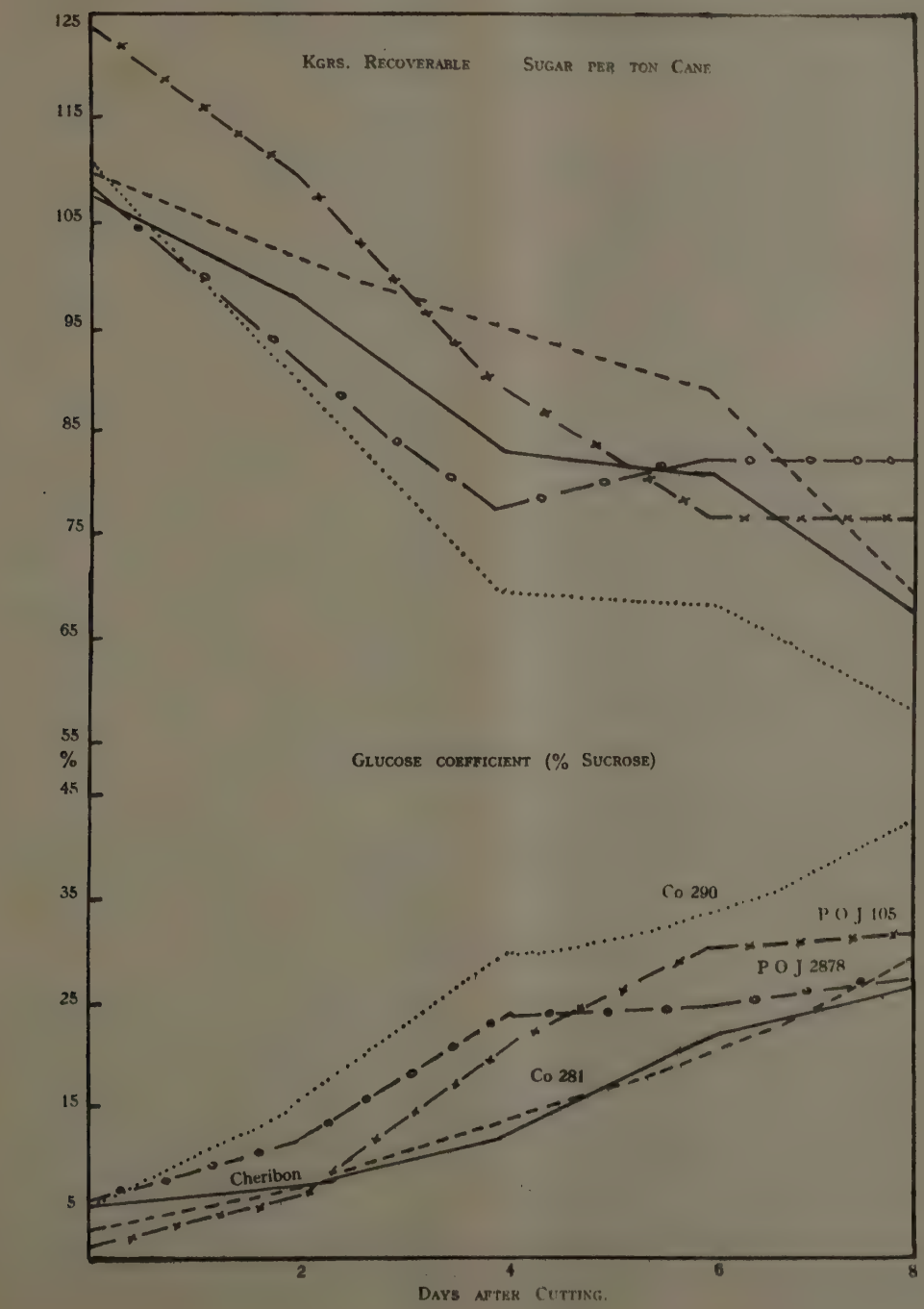


Fig. I.
EFFECT OF DELAYED DELIVERY ON CANE QUALITY.
%
20
15
10
5
Co 281
P O J 105
Cheribon
P O J 2878
Co 290
2
4
6
8
Days after Cutting.

FIG. III.

EFFECT OF DELAYED DELIVERY ON RECOVERABLE SUGAR AND GLUCOSE RATIO.



Considering first the loss of weight, it is evident, from Table III and Fig. 1 that, broadly speaking, this varies directly with the surface exposed to evaporation, or, in other words, inversely with diameter. Hence, we see the thinnest cane, Co 281, losing almost 12 per cent. of its weight in four days and 18 per cent. in eight, while the next slimmest, POJ 105, loses 10 per cent. and 16 per cent. respectively. It is interesting to note from Table I that these are almost identically the same average losses shown by POJ 105 in the Mallawi experiments.

As for the other three varieties, the figures after four days show no significant variations, all losing around 8 per cent. by evaporation. After eight days the differences are not large enough to be significant, particularly as the abnormal decrease in weight of POJ 2878 and Cheribon in the second half of the period might have some remote relation with the attractiveness of these two canes for "chewing" purposes, even though all possible precautions were taken against pilferage.

As regards actual deterioration, the four-day figures result in the order of merit classification shown in Table III, with the comparative trends clearly brought out in Figs. II and III. Co 281 justifies its established reputation and heads the class through losing less than 12 per cent. in purity and but 14 per cent. of its recoverable sugar against 15 per cent. and 23 per cent., respectively, for the slowly-inverting Cheribon. POJ 2878 appears to have lost slightly less in purity than the standard POJ 105, which is known to invert much more rapidly than the Cheribon canes, but the two POJ canes have both had their sugar-producing potential reduced by 28 per cent. And finally, Co 290 has confirmed previous indications of very rapid inversion by losing almost a quarter of its original purity and more than a third of its recoverable sugar.

While it must again be emphasized that these conclusions should be accepted with a certain reserve on account of their exploratory nature, the general trends established seem to confirm quite consistently present knowledge regarding the comparative keeping qualities of the distinct varieties.

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EXPERIMENTS WITH ROBUSTA COFFEE

G. W. Nye describes in the *E. Afric. Agric. Jl.*, 5 : 460-5, the results of some experiments with robusta coffee just within (10 miles) the northern limit of robusta cultivation in Buganda. The experiment plots were established in 1929. The single stem system proved superior to the multiple stem. Bananas could not be maintained as shade and *Gliricidia* proved unsatisfactory in growth and from the fact that it harboured mealy bug which dropped from the trees on to the coffee bushes. After five years of biennial bearing the trees had to be stumped, so that yields will be low until the stumped plots have fully recovered. Unshaded coffee yielded better than when shaded with *Gliricidia* or banana. Clean weeding gave increased yield and more regular yield over permanent cover crops, but the latter began recently to show improvement. Cropping is most regular under *Gliricidia* shade and more irregular under bananas than with no shade at all. Differences between annual mulching to a depth of one foot and clean weeding were not significant, but both are significantly better than weed cover and cover crop, and the cover crop is significantly better than weed cover. Mulch had a marked effect on reducing leaf fall, in soil conservation and reduction of weeding costs, but little, so far, in increasing yield. The yearly application of a petrol tin full of rotted cotton seed per tree gave a significant yield.—(*Hort. Abstracts*, X, p. 289.)

REVIEW

AGRICULTURE IN THE WEST INDIES

Compiled from Documents supplied to the West India Royal Commission 1938–1939, and other sources. Colonial No. 182. H.M.S.O., London, 10s. net.

"The compilation was undertaken by Dr. H. A. Tempany, C.B.E., now Agricultural Adviser to the Secretary of State for the Colonies. The sections, as completed, have been examined by Professor Engledow and have then been sent to the Colony concerned for final revision. The whole work is objective and presents an accurate picture of the position of West Indian agriculture as at the end of 1939."

This extract from the preface, written by Sir Frank Stockdale shows what the book is. It is a very good ten shillings worth of facts. The reader is left to make his own generalizations and to draw his own conclusions.

The book naturally presents a picture of the economic conditions of these Islands as well as of their agriculture just before the beginning of the second world war. Though the picture has few high lights, there are none the less very marked gradations in the chiaroscuro of its various sections. In the three larger Colonies the sugar-cane industry, always the mainstay (and most of the other stays as well) of the West Indies, had some forty years ago to meet the breaking strain of unfair competition from the heavily subsidized beet industries of the continent of Europe. The sugar planters met the strain by amalgamating their small estates, on various plans and to various degrees of combination, into large concerns which could erect big, efficient central factories, install rail transport, employ competent management, and quickly take advantage of improved varieties of cane and new methods of culture and extraction. In those Colonies, the sugar industry still provides the basis of at least moderate present prosperity and future hope. Similar plans were followed in those of the smaller islands where the topography presented no great obstacle to railroad transport. There again neither the present picture nor the future prospects are entirely black. It must be noted, though, that the future of these islands rests entirely on the prospect of post-war international regulation of the world's sugar market, in such a way that the unsubsidized and unprotected cane sugar of the tropics is safeguarded against a renewal of the excessive subsidization of beet sugar in the temperate countries. But in the smaller islands, which are most of them more or less mountainous, the old, small, sugar-cane estates occupied only scattered, specially favourable areas. In those islands the planters, faced with transport difficulties in addition to the other obstacles to amalgamation, never succeeded in uniting together to erect modern factories. A few small estates have survived, producing "fancy molasses" with simple equipment for a limited market, but generally their sugar industries are dead. In those particular islands, the present picture is indeed gloomy; and hope for the future has to rest upon the faith that it may prove possible, with expert guidance and financial assistance, to create a home-loving, stock-loving, soil-loving peasantry out of the present depressed populations of under-employed labourers and landless share croppers. And the hope of creating such a peasantry depends, in turn, on the introduction of a new system of mixed farming based on strip cropping, alternate husbandry and stall feeding—a system of which the technical details have still to be worked out by experiment or of which at least the practicability has still to be convincingly demonstrated.

On almost every page, even of the sections dealing with the larger islands, the need is implicit or explicit for the improvement and development of the normal activities of an Agricultural Department—investigation, experiment, demonstration, marketing organization. But from the pages dealing with the smaller islands, with perhaps one exception, the need for such development cries out even more loudly, as one reads the statement of the known facts, and—still more illuminative—the many paragraphs in which it has to be stated "no information is available about" this or that. "This" or "that" being matters of such economic importance as the characteristics of a soil or the correct manuring or best cultural treatment of a crop. It will be no easy matter to provide efficient technical agricultural services for these islands, each with populations of only five to twenty thousand inhabitants or so and a cultivable area of a similar number of acres; but each of which is generally divided by climate and topography into several separate areas with widely differing conditions!

One notices one omission in this otherwise very complete compilation of facts and figures, namely the absence of any data about daily wages or the earnings of agricultural labour. Presumably no information is given of these matters, because of the difficulty of really presenting the truth, the whole truth and nothing but the truth in a few words and figures. But it is to be regretted that no estimates at all are given in respect of these figures. For while the daily wage rate of an agricultural labourer does not put the whole economic structure of an agricultural country into a nut shell, there is no other single figure which tells one so much. Similarly it is only in respect of one or two of the colonies that *per capita* figures are given of agricultural exports, let alone total agricultural production. And, again, although such figures are not complete criteria of the efficiency or prosperity of a country's agriculture, they go a long way towards placing the picture of the country's agriculture in its proper perspective. But it is ungenerous to complain of omissions from a book which constitutes such a monumental labour of compilation and compression.

O. T. F.

HOW PLANT BREEDING PROGRAMMES COMPLICATE PLANT DISEASE PROBLEMS *

THE present interest in breeding crop plants, together with present means of wide and prompt dissemination of new varieties bids fair to complicate still further disease problems, whether of control, prediction or even of estimation. Given a fairly stable agriculture based on varieties long established in a region, serious fluctuations in the severity of a disease, the kind which are of great economic importance and incidentally of much scientific interest, usually were induced in one or two ways—a marked change in the weather for a longer or shorter period, or the appearance, by hybridization or mutation or by actual introduction, of a new parasite. So generally has this been the case that some pathologists have found an apparent relation between the age of an agriculture and the losses from plant disease. To these students it has seemed that plant disease losses were greater in the regions of newer agriculture.

The list of tragic losses in important economic plants due to introduced insect pests and plant diseases is a long one, too well known to need repetition here. Of the converse process, a serious outbreak of a disease or an insect pest following the introduction of a susceptible variety into the domain of a potentially serious parasite, the history of the potato beetle is perhaps the best known example.

If the historical accounts are correct, the potato beetle acquired its appetite for potato plants very soon after the introduction of the new host. The corn-borer was apparently more deliberate and according to Wardle (1), "We have historical evidence that the corn-borer thirty years ago was in southern Germany a pest of hemp and hops, and that since its adaptation to corn, it will not seriously attack hemp and hops, even when these plants are grown in close proximity to heavily infested corn fields." Of course, the slightly more than four centuries during which corn had then been cultivated in Germany is really a short time compared with the more than forty centuries which de Candolle believes hemp had been cultivated, but it is entirely too long to be regarded as a practicable test or quarantine period.

To these two well-recognized methods by which the incidence of losses due to disease and insect pests is strongly influenced, namely, weather changes and introduction, there is now being added, I believe, a third, the work of the plant breeders. It may be worth while to consider future possibilities on the basis of past performance, the only method yet devised for any intelligent appraisal of the future.

On the basis of past performance we may reasonably expect interesting developments in the distribution of disease-producing organisms. As an example of this may be cited the case of the introduction into the northern states of the nematode which causes summer dwarf of strawberries. In the spring of 1930 strawberry plants of the then new and highly regarded variety, Blakemore, were shipped from a region where this type of strawberry dwarf was common (2) to many points outside its known range. Apparently no complete survey has been made since 1931, but the subsequent careful work of Christie (3) leaves little doubt that the disease then introduced into the eastern shore of Maryland is gradually becoming less abundant.

Now that breeding for disease resistance attracts so much attention, we must expect the introduction and rapid dissemination of varieties very resistant to certain diseases. Examples of this are easily recalled. Since they represent a distinct economic gain and disturb no one but the student of plant diseases, they get much attention elsewhere and require little here.

Two closely related results of breeding programmes which seem worth special consideration are the introduction on a commercial scale of varieties very susceptible to certain, sometimes new, diseases and the modifying effect of new varieties on parasites long known to be of commercial importance.

At first sight, to speak of the introduction on a commercial scale of varieties very susceptible to certain diseases may seem like a criticism of our breeding programmes, but it is not so intended. I struggled with this problem for several years, and became convinced that with our available knowledge, it simply is not possible so fully to test our new varieties as to offer assurance that some of them will not sooner or later prove very susceptible to some disease. This should not be interpreted as condoning any laxity in tests for disease resistance which, of course, should be conducted with all possible completeness and severity, but the number of potential pests is so great and the conditions under which they might become serious so varied that any all-inclusive test would take so long and would require culture under so wide a range of environmental conditions as to be wholly impracticable. Just as the real test for a new model of automobile is the road test in the hands of the first twenty to fifty thousand owners, so the real test of a new variety is its culture in the hands of ten to twenty thousand farmers.

(1) R. A. Wardle, "Problems of Applied Biology." 1929.

(2) N. E. Stevens and P. V. Mook, *Jour. Econ. Entomology*, 25: 447-454, 1932.

(3) J. R. Christie, *Jour. Agric. Res.*, 57: 73-80, 1938 (and earlier papers therein cited).

* Article by Dr. N. E. Stevens, Professor of Botany, University of Illinois, reproduced from *Science* Vol. 95, No. 2465, 1942.

As evidence on this point, I would like to quote from the summary given by Stackman, Christensen and Becker (4) of the experience in the spring wheat area of the United States of America during the last 25 years. These writers say, "During the time of observation at least twenty new varieties of wheat were introduced into the spring wheat area and almost every one brought new disease problems with it, or at least changed the old ones". As specific examples they point out that for many years Haynes, Glydon and Preston were the wheat varieties commonly grown. Stem rust and bunt were then the only really important diseases. When Marquis replaced these varieties over a wide area bunt no longer played any rôle and stem rust seemed somewhat less serious, but scab, which earlier did not have any significance, suddenly became predominantly important, since the new variety was much more susceptible to this disease.

Somewhat later Hope and H-44, neither of which is in the opinion of these authors a very good variety, were introduced. These are in general more resistant to most of the harmful diseases of spring wheat than any other varieties now available, and are being extensively used for crossing. However, there appears to be a strong linkage in many of these crosses between rust resistance and susceptibility to black chaff to which Hope and H-44 are much more susceptible than any other spring wheats which have been observed up to that time. Just as the widespread planting of Marquis made scab of real economic importance, so the widespread planting of Hope and H-44 might make black chaff of real economic importance.

In the same paper these authors review the situation regarding barley and state that the disease problem in the case of this crop has changed repeatedly with the introduction and culture of new varieties. In discussing the varieties Velvet and Glabron, which were introduced in 1926, they say "but after these varieties were generally grown for several years it was observed that they were very susceptible to loose smut and scab (p. 62). This latter disease is dangerous because it not only greatly lessens the yield in the case of an epidemic, but also makes the variety useless for feeding to swine because of its toxicity (p. 63)".

What may perhaps be regarded as the converse of the relation just described is the effect on parasite populations resulting from the introduction of new host varieties, varieties which by their popularity replace those previously grown and thus make inevitable the development of certain strains of these parasites previously so rare as to be insignificant or even unknown. Here again the work of Stakman and his associates furnishes a good example. Who can fail to connect the increase in form 56 from 0.2 per cent. of the rust population in 1930 to 30 per cent. of that population in 1934 with the coincident great increase in the planting of Ceres wheat, first released in 1926, to which variety stem rust proved so disastrous in 1935 ?

In considering future possibilities regarding plant diseases it would be folly to exclude what is in some ways the most significant and far-reaching change in a crop plant in our generation, the very general planting of "hybrid" corn. Unless you live in the corn belt it is difficult to comprehend the speed and extent of the spread of the vogue of hybrid corn. According to Dr. McCall's report to the chief of the Bureau of Plant Industry, 1939, the approximate acreages of hybrid corn were 500,000 in 1935, 1,500,000 in 1936, 3,500,000 in 1937 and 17,000,000 in 1938. In 1939 at least 25,000,000 acres of corn in the corn belt were planted to hybrid seed (5).

It seems hardly possible that so profound a change can be made without altering the disease relations of the crop. This replacing of open-pollinated corn with hybrid corn fits into the problem we have under consideration in at least three ways. First, in the matter of introducing new varieties very susceptible to certain diseases. If any one imagines that the new varieties, or at least new numbers, of hybrid corn introduced into the corn belt during 1939 and 1940 were so thoroughly tested that their disease relations could be predicted, his knowledge of human nature is even more limited than his knowledge of corn diseases. Nor need we wait for the distant future or for the action of unknown diseases on untested hybrids for evidence of extreme susceptibility. Witness, for example, the havoc worked in Hybrid 960 during 1938 by bacterial wilt and Diplodia stalk rot.

Two of the most experienced entomologists in the Middle West assure me that a somewhat similar condition has been noted with relation to at least one insect. According to these observers, the corn leaf aphid, *Aphis maidis* Fitch, was of relatively minor economic importance for many years prior to the introduction of hybrid corn. During recent years, however, with the introduction of a number of very susceptible hybrids the importance of this insect has greatly increased.

What about the effect of hybrid corn on corn parasites ? The change in wheat rust in response to the change in the host population was made possible by the variation continually going on in the stem rust organism itself. Corn parasites vary too, some of them, no doubt, even more actively than in any wheat parasites. That the organism which causes bacterial wilt of corn is made up of a large number of strains, among which there is definite selection on repeated passage through a resistant host, has been proved by McNew (6) and by Lincoln (7). McNew has further shown

(4) E. C. Stakman, J. J. Christensen and Hanna Becker, *Der Zuchter*, 10 : 57-68, 1938.

(5) H. A. Wallace, *New Republic*, November 8 1939.

(6) G. L. McNew, *Phytopath.*, 27 : 1161-1170, 1937.

(7) R. E. Lincoln, *Science*, 89 : 159-160, 1939.

that slightly virulent cultures become more virulent after they have grown on certain media (8).

Just how different the host environment of the wilt organism is in the north-eastern sweet-corn-growing states from its environment in the same region ten years ago can be understood only if we review the history of Golden Cross Bantam. This is a single cross made up of two inbred lines, Purdue 39 and Purdue 51. In 1931 seed of this extraordinary hybrid, developed by Glenn M. Smith, was distributed to 61 interested growers in 20 states. Its progress since that time may be best traced from the details in Table 1.

Year.	Golden Cross bantam seed produced in pounds.	Yellow Corn canned.		Proportion of all sweet corn hybrids used for canning which were Golden Cross Bantam.
		Open pollinated.	Hybrid.	
		%	%	%
1932	2,000	...	...	...
1933	350,000	69	31	...
1934	600,000	57	43	67
1935	1,250,000	38	62	73
1936	1,500,000	27	73	72
1937	1,500,000	21	79	70

These figures were taken from reports of the Raw Products Bureau of the National Canners Association. Accurate figures for subsequent years are not available and may never be since there is a suspicion that Golden Cross Bantam is now being produced and sold under other names.

Not less remarkable than the rapid increase in total acreage is the wide range throughout which Golden Cross Bantam proves to be adapted. It is now in successful large-scale commercial production from Illinois east to and including New York and south through Maryland. Indeed in Maryland it makes up about 40 per cent. of the total crop of sweet corn for canning, although open pollinated Golden Bantam was given up there prior to 1930 because of bacterial wilt. Golden Cross Bantam is now being grown successfully on a commercial scale in Oregon and Eastern Washington and in Western Idaho, though that is not important in the present relation.

The important point here is that from Illinois to the eastern seaboard, throughout practically all the region in which bacterial wilt was so destructive on sweet corn in 1931–1933, its host environment, so far as sweet corn is concerned, has become quite different. Instead of open-pollinated corn, so variable as to become locally adapted and not profitably planted far from the point of production, we have a very uniform single cross dominating sweet corn production over at least a thousand mile belt. Given a parasite which we know to be highly plastic, can any reasonable person assume that the population of this organism to-day can be the same as in 1931 ?

At some risk of seeming to attempt the dramatic I would like to emphasize the fact that the past decade is the first in the history of agriculture when one could speak of the modification of a corn parasite by a uniform host environment on a scale large enough to be readily observed, and expect to be taken seriously. I believe it may be literally true that never before in the history of corn culture has a corn parasite been exposed over a wide range to so uniform a host environment. Biologically, including of course its disease relations, we are transforming Indian corn from a freely cross-pollinated crop to a synthetic product.

Elsewhere I have pointed out a relation (9) which may indeed have been all but self-evident, namely, that among comparable crops there is a demonstrable difference as regards disease losses between open-pollinated crops produced from seed and similar self-pollinated crops, disease losses fluctuating more and being in general of greater importance to those plants which are largely self-pollinating.

In a field of open-pollinated corn, there is, I am told, even in the named varieties a wide range in genetic composition and, no doubt, also variation in susceptibility to many diseases. In such a field there is an observable variation in the time of silking and tasseling, and in the time at which plants reach a stage of susceptibility to infection by certain diseases. In contrast to this a field of "hybrid corn" is much more uniform in these respects.

To be sure, the corn now planted consists mostly of double crosses which are somewhat more variable in time of silking, etc., than single crosses. Certain careful growers also plant two crosses in a single field in order that they may still further reduce the hazards due to too great uniformity.

More important in relation to disease and disease-producing organisms is the fact that up until the last few years Indian corn apparently has been able to vary and adjust itself about as rapidly as the disease organisms themselves. Recent researches have shown that in general the common smut of corn, like most smut fungi, is parasitic only in the dicaryon stage, that is, it must cross to parasitize ; that it is extremely heterozygous for many characters and consequently unstable ; that variation is so common, even in unisexual lines, that from a single monosporidial line more than 150 distinct variants have been isolated ; that different combinations of monosporidial lines differ greatly in their degree of pathogenicity and that some of them are so virulent as to kill the host outright.

No one supposes that this ability of the smut fungus or other fungi is recently acquired. It is very much more likely that the process has been going on for many centuries. It is hardly to be doubted that exceedingly virulent lines of smut may occasionally have appeared during these centuries, yet Indian corn survived and has been

(8) G. L. McNew, *Phytopath.*, 28 : 769-787, 1938.

(9) N. E. Stevens, *Science*, 89 : 339-340, 1939.

grown during recent years with a minimum of effective disease control, and apparently much less loss from disease than in the case of wheat (10).

In corn we are dealing with a native plant, or at least one long cultivated in this area. In many of the places where we now grow corn, our Indian predecessors grew the same plant, which held its own against these same diseases when our ancestors were suffering from the black plague or arguing about the Post-Columbian pandemic of syphilis. All that is now changed and I believe permanently changed. Hybrid corn is here to stay. The increased yield, together with the ease with which seed is produced, makes its future all but certain. Almost equally certain seems to me the probability that we are changing the disease relations of this great crop.

By the wide use of hybrid corn we are depriving this important crop of its power of taking care of itself and by continued crossing and variation, continually adjusting itself to the equally variable parasites which attack it, and have substituted our own choice of parents for each field. In view of our none too brilliant record of success in so testing varieties of other grains as to ensure them against loss from disease when planted over a wide acreage, it seems unlikely that we will have much greater success in dealing with corn. It seems much more probable that in spite of the best efforts of the breeders we will see for some years in hybrid corn a disease relation more nearly resembling that in wheat ; that is, wider fluctuations in losses with some years very little damage and in others greater damage than has heretofore been observed. Eventually we may see lower average disease losses, but I sincerely believe that our corn breeders will be doing all that can reasonably be expected of them, if during the next ten years they keep the losses from disease in the new varieties, including losses in decay after harvesting, down to the general level of such losses in the old open-pollinated varieties.

(10) N. E. Stevens, *Scientific Monthly*, 52 : 364-366, 1941.

PHYSICAL RESEARCH ON PROBLEMS OF SOIL CULTIVATION

[Below will be found an extract from an article under the above title by Dr. B. A. Keen, which was published in 'Endeavour', Vol. I, No. 2, April, 1942. In this article Dr. Keen challenges many traditional ideas about agricultural methods. In particular he brings evidence to show that, contrary to deeply ingrained tradition, crop yields are remarkably insensitive to variations in cultivation ; and that the attractive "capillary tube" theory of the movement of soil moisture is entirely untenable.]

"Modern science has shown, therefore that cultivation operations have only a minor influence on the moisture regime of the soil and, in consequence, much of the traditional belief on this subject must be abandoned or recast. When these traditions are examined closely it is seen that although they embrace the three factors, cultivation, moisture, and plant growth, many are short-circuited into a direct relation between cultivation and plant growth. The gardeners' exhortation to 'keep the hoe moving among the crops' is a familiar example, and it is no exaggeration to say that most farmers believe that their crops will suffer by just the amount that their cultivations fall short of perfection. The belief was instinctive. The art of cultivation was well established long before agricultural science developed, and the practical man naturally felt that the operations were so obviously fundamental as to lie right outside any need for experiment. In settled countries innumerable field experiments have been made on artificial fertilizers and the number of such tests is still increasing, but experiments on cultivation were hardly ever made ; yet the costs of cultivation are the heaviest single item in the arable farmer's budget and far exceed those for artificial manuring. In countries where agricultural development came later, experiments on cultivation were made, notably an extensive series in the Great Plains region of America, but the results were ignored in this country for the apparently adequate reason that as they were done in an area of low rainfall, the conclusions could not possibly apply to our own conditions.

Such was the position some dozen years ago, when cultivation experiments were begun at Rothamsted. The main results are briefly summarized in the next paragraph.

Subsoiling is a standby of many heavy-land farmers, but on the Rothamsted soil, which has a heavy clay subsoil, the operation produced no effect on sugar-beet. The normal preparation for root crops includes both autumn and spring ploughing, and if bad weather prevents the autumn ploughing some apprehension is felt as to the quality of the spring seed-bed ; tests made with potatoes and sugar-beet as the crop showed that the double ploughing gave only an insignificant increase of yield over a single ploughing, and not nearly enough to pay for the cost of extra work. Deep ploughing every year was no more effective than shallow ploughing, but there was slight evidence that an occasional deep ploughing gave a little increase in the yield of root crops. The nature of the seed-bed itself was also studied and it was found that it had little influence on the final yield. Many experiments have been done on the inter-row cultivation of root crops, in which the minimum hoeings necessary to keep down the worst of the weeds have been compared with a greater number of hoeings. For a number of years the result of the extra hoeings was either

no increase in the crop or, more often, a significant reduction in yield, a result due in all probability to the inevitable damage done to shallow-feeding roots. In some of the later experiments on inter-row tillage an increased yield was sometimes obtained. The design of the experiments enabled this positive effect to be traced to one hoeing done in the early stages of plant growth, and the effect has been confirmed in experiments on another type of soil. It suggests that farm and garden crops are specially sensitive to weed competition in the early stages of their growth and that one hoeing then is worth many afterwards.

The net result of all this work is to show that, provided the crop has a reasonably fair seed-bed, that it is given a hoeing in its early stages, and that the worst of the later weeds are kept down, then any cultivation of the soil—whether before sowing or during growth—in excess of this minimum is of little direct value to the plant. The results are in harmony with those reached by the investigators on the Great Plains area, and they are in harmony with modern knowledge of soil physics. They are in conflict with a deeply ingrained tradition."

CHEMICAL NOTES

(Compiled by the College Department of Chemistry and Soil Science)

Carrots for Domestic Animals

War conditions have established the merits of carrots as an ingredient of the human dietary: that they are no less excellent as a food for farm animals, is shown in a recent article by Mr. H. E. Woodman, of the School of Agriculture, Cambridge (*J. Min. Agric.*, 48, No. 3, 185: 1941). Indeed all kinds of stock are fond of carrots, and although their importance in animal feeding is overshadowed by that of the other root crops—swedes, mangolds and turnips—this is not due to any inferiority in feeding quality, but rather to price considerations and to the fact that when the human requirements have been met, the supply of carrots left over for animals has usually been quite small. On the basis of starch equivalents 80 lb. of carrots should be able, on an average, to replace 100 lb. of mangolds, or 90 lb. of swedes. With the more watery turnips, however, two parts by weight may be replaced by one part of carrots. Carrots are not so rich as swedes in vitamin C, the anti-scurvy-factor, but are distinguished from all other roots by their high content of carotene. Since this yellow pigment is convertible into vitamin A in the body of the animal, it follows that carrots are a good source of this important health factor.

Raw carrots have always been a favourite food for horses. The allowance should not exceed 20 lb. per head per day, but smaller amounts may be fed with benefit to condition. They should be used in partial replacement of oats, 7 lb. of carrots being equal to 1 lb. of the cereal. Dairy cows may receive up to 40 lb. of sliced carrots per head per day and fattening bullocks up to 60 lb. The carotene in the carrots enriches the colour of winter milk and improves its content of vitamin A, and for this reason, carrots are specially valuable when the dairy ration contains neither kale nor silage. They may be used to replace dried sugar-beet pulp (7 lb. of carrots = 1 lb. of dried beet pulp) or cereals (8 lb. of carrots = 1 lb. of crushed barley). Pigs may also be given carrots with advantage to health and condition; and cereal meal up to one-fifth of the total ration, may be replaced by this succulent food, of which 8 lb. should be fed for every pound of cereal meal replaced. The carrots form a useful source of vitamin A for pigs that are kept entirely indoors. Some authorities recommend cooking or steaming them for pigs, but the full beneficial effect is only obtained when they are fed raw. Grated or shredded carrots, when mixed with the meal ration, provide a palatable and health-promoting feed. Carrots form a useful supplement to the growing and laying mashes of poultry during winter, and their vitamin A potency is particularly beneficial in these cases. They are best fed raw. Grated or shredded carrots may replace cereals up to one-fifth of the total mash, 8 parts by weight being used to replace 1 part of cereal. —(*Nature*, Vol. 149, No. 3772, 1942.)

* * *

Industrial Uses of Cashew

C. M. John in an article in the *Madras Agr. J.* 29, No. 5, collates the recorded uses to which the cashew can be put. The chief of them are given below. The nut is used in a variety of household preparations and has a high biological value. The kernel contains 40 per cent. of oil of high nutritive value, superior to olive oil. The shell oil is used in preparation of varnishes and similar products. Anacardic acid, which forms 90 per cent. of the corrosive oil, has lately been used as an antiseptic for textiles. The apple has anti-scorbutic properties and the invert sugars are valuable for inclusion in infant and invalid foods. Mixed with iron sulphate the juice is said to make a good hair dye. Cashew wood is used for making boats and packing cases. The resinous gum from the bark repels insects and can therefore be used in bookbinding. The sap obtained from incisions on the bark makes an indelible marking ink. The charcoal is much esteemed by local ironsmiths.